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# **Quantitative Risk Assessment of BSE in the United States**

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## Executive Summary

Bovine Spongiform Encephalopathy (BSE) is a major new cattle disease problem. The current hypothesis suggests that BSE is the clinical manifestation of the sheep scrapie agent in cattle. While the disease has not been definitively diagnosed in the United States, sheep scrapie does exist along with the feeding of rendered sheep products to cattle.

A qualitative analysis comparing risk factors of the United States and United Kingdom provided little evidence to support a broad risk of BSE at the national level<sup>1</sup>. However, the focus was on the aggregate level and did not address regional differences in the livestock production and related slaughter, rendering, and feed industry practices.

This quantitative risk assessment was developed around a systems model of BSE. The model incorporated regional differences in sheep and cattle demographics, scrapie disease status, rendering, and feed industry practices. To identify levels of risk, a worst case scenario was defined by assuming that all meat and bone meal produced from mature sheep offal is mixed in dairy concentrate feeds. Relative risk was measured as the ratio of dairy concentrate fed to mature sheep meat and bone meal produced. The higher the ratio, the lower the potential risk. At the national level this ratio was 34,760 or over 17 tons of concentrate fed to dairy cattle for each 1 pound of sheep meat and bone meal produced. At the State-level the ratios varied from 1,252 to 54 million. At the county-level, the range was from 22 to over 10 million.

The inclusion of meat and bone meal into least-cost feed formulation is dependent on price and palatability. Seven of the top 10 States with the lowest ratio of dairy concentrate fed to sheep meat and bone meal produced (highest risk) can produce more meat and bone than is actually used in feed. Such net surplus States may likely have lower prices and higher rates of inclusion when compared to States which must import. Overall, States with relatively few dairy cows but substantial mature sheep rendered, may be at higher risk than States with large dairy populations.

To address regional differences, rendering trade areas were defined as the county and contiguous counties in which each rendering plant was located. The assumption was that mature sheep meat and bone meal rendered was fed to dairy in each defined area. This approach captured 50 percent of all United States dairy cows but biased upward the potential level of risk. Areas where the ratio of dairy concentrate fed to sheep meat and bone meal produced was less than 100 were considered at highest risk. Only 0.06 percent of all dairy cows were in counties with ratios below 100 and 0.8 percent were in counties with ratios below 1,000. On a regional basis, the largest number of cows in the high risk areas were located in the Upper Midwest.

To incorporate scrapie in the risk assessment, six risk categories were identified based on the reported presence of scrapie by county and the number of dairy cows with low ratios of dairy concentrate fed to sheep meat and bone meal produced. Six States had at least one county with documented scrapie along with dairy cows located in a rendering area with a ratio less than 1,000.

Despite wide geographic variation in concentrates fed and sheep meat and bone meal produced, little evidence existed to support a broad risk of BSE among a large portion of the dairy population. This was evidenced by the relative small amount of mature sheep meat and bone meal produced. In interpreting these results, consideration should be given to the simplifying assumptions surrounding the rendering trade areas and feed formulation. Also, this analysis assumes that infected sheep were the sole source of the BSE agent.

<sup>1</sup> *Qualitative Analysis of BSE Risk Factors in the United States*. USDA:APHIS:VS, January, 1991.





Bovine Spongiform Encephalopathy (BSE) represents a major new cattle disease problem. The disease has been diagnosed in the United Kingdom, Ireland, Oman, and Switzerland. The current leading etiologic hypothesis suggests that BSE is a cattle variant of the sheep scrapie agent. Exposure of cattle to scrapie originated through the feeding of infectious rendered product from scrapie-infected sheep. Although the disease has not been definitively diagnosed in the United States, sheep scrapie exists as does the feeding of rendered sheep products to cattle.

A comparison of the BSE risk factors between the United States and the United Kingdom facilitated a qualitative analysis of the risk of BSE within the United States<sup>1</sup>. Similarities exist in rendering processes in the two countries, however, major differences are evident in the sheep and cattle demographics, relative slaughter of sheep and cattle, rendering industry, feeding practices, and composition of feed concentrates. The qualitative analysis of these risk factors suggests little evidence for a broad risk for BSE within the United States as a nation. Nevertheless, regional and temporal differences in the livestock, slaughter, rendering, and feed industries suggest that the risk is not homogeneous throughout the United States.

This quantitative risk assessment develops a systems model of the epidemiology of BSE. Regional differences in the current United States sheep and cattle demographics, scrapie disease status, rendering practices, and feed industry are incorporated into the model in order to identify specific regions of the country in which BSE has the highest risk of occurrence.

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<sup>1</sup> *Qualitative Analysis of BSE Risk Factors in the United States*. USDA:APHIS:VS, January, 1991.



# Systems Model of BSE Epidemiology

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The leading hypothesis for the transmission of BSE can be diagrammed with a systems model (Figure 1). Cattle are exposed to the scrapie/BSE agent orally through contaminated animal protein feedstuffs. The feedstuffs become contaminated with infectious material by importation of contaminated protein concentrates from BSE affected countries or by incorporation of domestically- produced contaminated protein concentrates. Contamination of the rendered products occurs when scrapie-infected sheep or BSE-infected cattle or the offal from infected animals are processed by the rendering industry. The agent survives the rendering process to enter the animal protein concentrates.

The systems model for the United States can be simplified after careful evaluation. Only a small amount of animal protein products enter the United States from known scrapie or BSE affected countries, therefore, this contribution appears to be negligible. Importation of live animals from BSE affected countries has been very limited. Further importation has been cancelled and traceback of animals imported over the past 10 years has not identified any clinically affected animals. Consequently, this potential contribution to the systems model appears to be negligible.

The major contributors to the BSE systems model in the United States appear to be domestic scrapie-infected sheep (Figure 2). Infected sheep enter the animal feed chain through the rendering industry, either as offal generated through commercial slaughter or directly through the rendering of dead, dying, or diseased individuals. Rendered sheep products are incorporated into animal protein concentrates and enter cattle feeds as a protein source. Cattle ingest the infectious rendered product. Although the infectious dose is unknown and the oral route is not very efficient, this appears to be the route of infection. If cattle are being infected, then the agent may be recirculated through the rendering of cattle. Subclinically infected cattle generate offal at slaughter and clinically affected animals proceed directly to rendering.

The critical control points in the systems analysis for the United States are:

- 1) the provision of scrapie infected sheep and BSE infected cattle to the rendering industry;
- 2) the survival of the agent through the rendering process; and
- 3) the incorporation of infectious material into animal protein products such as meat and bone meal.

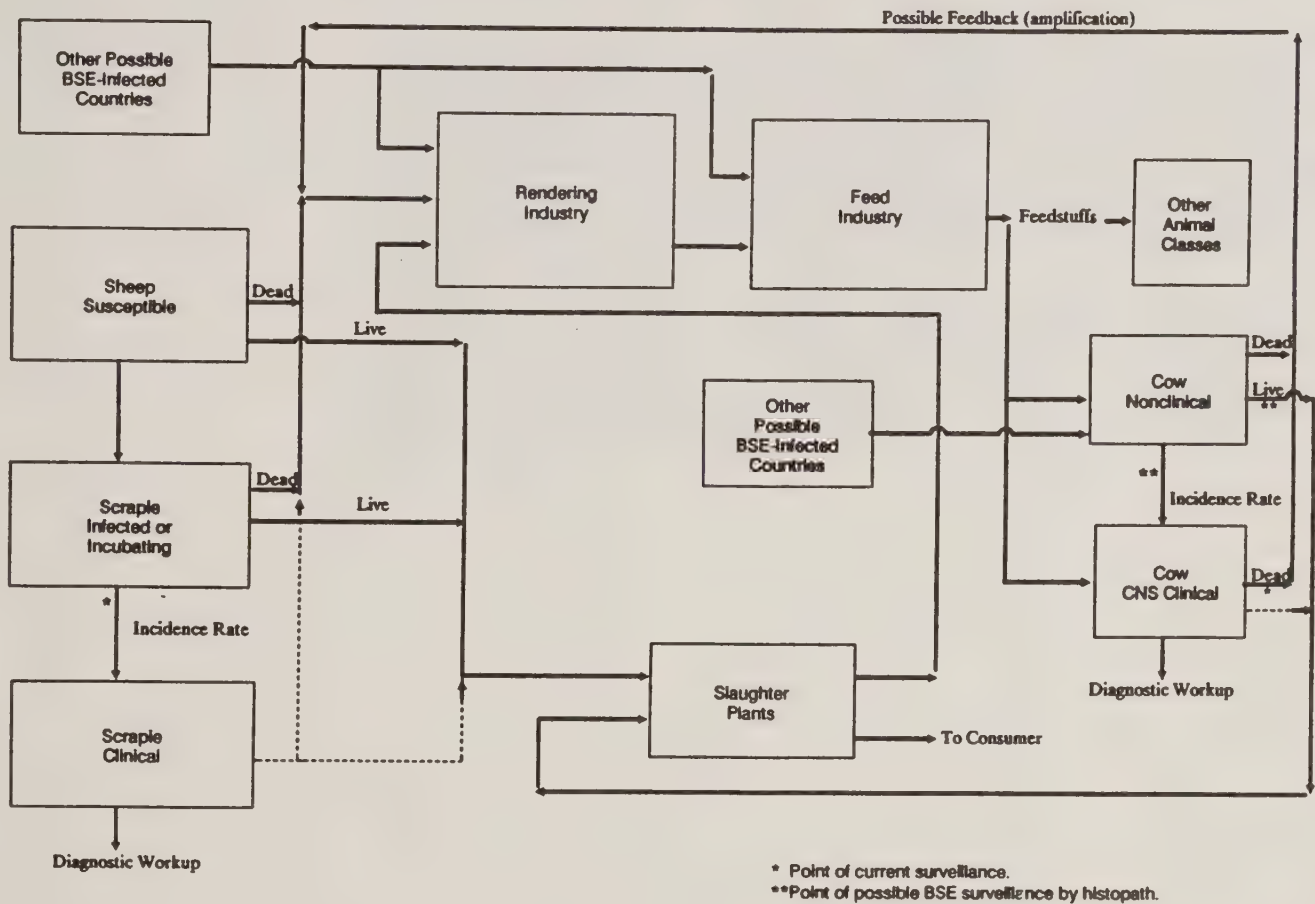
The infectivity of the final animal feed depends on both the concentration of the scrapie/BSE agent in the rendered product and the relative amount of infectious rendering animal protein in the feed. The survival of the scrapie/BSE agent in the rendering process is an accepted factor in the quantitative risk assessment. Therefore, regional and temporal influences at the other two critical control points, scrapie/BSE contamination of rendered product and infectious rendered product incorporation into cattle feeds, form the basis for the quantitative risk assessment.





Figure 1

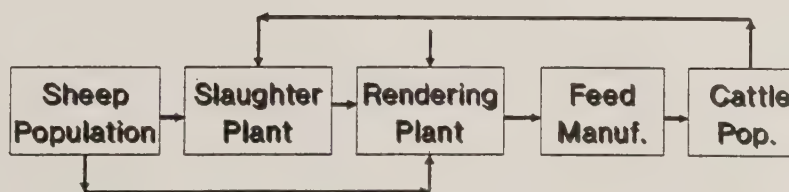
### Systems Model of Hypothesized BSE Epidemiology and Surveillance NAHMS 7/25/90



USDA-APHIS-VS-NAHMS

Figure 2

### Systems Model of BSE Epidemiology (U.K. Hypothesis)







## Scrapie/BSE Contamination of Rendered Product

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No clinical or subclinical BSE cases have been definitively diagnosed within the United States, so that the feedback or amplification route appears to be of minimal importance relative to the direct route of scrapie infected sheep entering the rendering process.

The cumulative incidence of scrapie in sheep over the last decade provides an initial indication of the likelihood of infected sheep by region (Figure 3). The ratio of documented scrapie-infected flocks over the past 10 years compared to the current ewe population is significantly higher for the States east of the Mississippi River compared to the western States. Sixty-nine percent (69%) of the eastern States had a ratio greater than 0.24 infected scrapie flocks per 10,000 ewes compared to 27 percent of the western States. No scrapie infected sheep have been reported in 13 of the contiguous 48 States over the past 10 years.

Scrapie is a disease of mature sheep (> 1 year of age). Review of United States scrapie program records and the Veterinary Medical Database reveal less than 7 percent of the scrapie diagnoses in ewes less than 24 months of age (Figure 4). Therefore, offal from mature sheep slaughter and pickup of dead, diseased, and downer mature animals constitute the major source of scrapie contamination of rendered product.



Figure 3

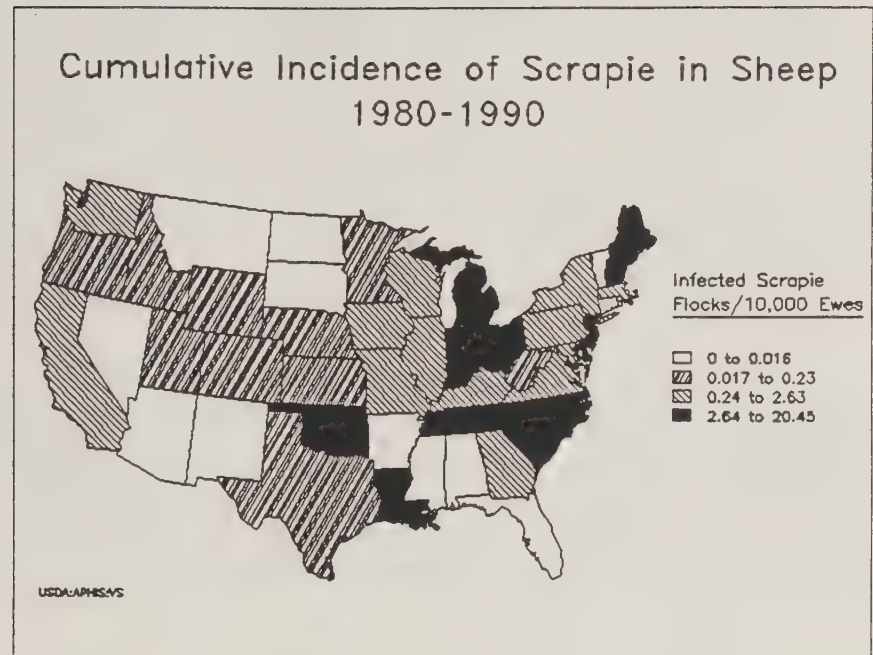


Figure 4

Age Distribution of Sheep Diagnosed with Scrapie - U.S.		
<u>Age</u>	<u>Number</u>	<u>Percent (%)</u>
< 17 Months	0	0
17 to 24 Months	48	6.9
25 to 36 Months	239	34.3
37 to 48 Months	254	36.4
49 to 60 Months	89	12.8
61 to 72 Months	43	6.2
> 72 Months	24	3.4

USDA:APHIS:VS Source: USDA:APHIS:VS





# Infectious Rendered Product Incorporated into Cattle Feeds

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Rendered animal-derived protein products are incorporated into cattle feeds as a protein source. Concentrations of scrapie are highest in brain and lymphatic tissues and extremely low or absent in blood and muscle so that meat and bone meal appears to be the rendered product of highest risk for incorporation into cattle feeds.

The rendering industry in the United States appears to be very localized, with hauling of raw materials within a 100-150 mile radius. As with other basic commodities, transportation of meat and bone meal is an important cost factor. The value of the meat and bone meal is tied to the price of feedgrain protein concentrates such as soybean meal. Incorporation of meat and bone meal into cattle concentrates depends on relative prices of other commodities as factored into least-cost ration formulations.

Although most United States cattle receive concentrates, the most intensive concentrate feeding occurs with feedlot and dairy cattle. Feedlot cattle receive concentrates during the growth and finishing periods, while dairy cattle receive the highest levels of concentrate during peak milk production. Meat and bone meal does not appear to be incorporated into calf starter rations. The incubation period of BSE is postulated to be 2.5 to 8 years. Consequently, feedlot cattle which are routinely slaughtered by 14-16 months of age are highly unlikely to demonstrate clinical signs of BSE even if infected.

## General Parameters and Assumptions of the Systems Model

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The systems model incorporated 7 major assumptions concerning scrapie contamination of the rendering process and the incorporation of infectious materials into cattle feed:

- 1) only the direct route of contamination of rendered product, i.e., scrapie infected sheep, was considered;
- 2) only mature sheep were considered as potentially scrapie infected;
- 3) all offal from mature sheep slaughter was considered to be processed at the nearest renderer;
- 4) dead, diseased, or downer mature sheep entered renderers in the same or contiguous counties only;
- 5) all mature sheep meat and bone meal was considered to be infectious;
- 6) only dairy cattle were considered to be at risk; and
- 7) all of the mature sheep meat and bone meal produced is fed to dairy cattle in the same county or contiguous counties in which the product was produced.

These assumptions outline the **worst case scenario** given the current BSE hypothesis. The purpose of building the model with these assumptions is to identify areas of greatest risk for the occurrence of BSE within the United States.





## State-Level Quantitative Risk Assessment

The state-level quantitative risk assessment estimated the total dairy concentrate fed, the total mature sheep meat and bone meal produced, and computed the ratio of dairy concentrates fed to the mature sheep meat and bone meal produced. The computed ratios ranged from 1,252 to 54,554,117 for the 48 coterminous States (Figure 5). The areas with the lowest ratios represent the highest risk, for example, the lowest number of pounds of dairy concentrate fed per pound of mature sheep meat and bone meal produced.

A second component of the state-level analysis addressed product availability and usage in formula feeds. The incorporation of meat and bone meal into least-cost feed formulation is dependent on price and palatability. The larger the ratio of meat and bone meal produced compared to the meat and bone meal usage in formula feeds, the more likely that the price will be lower and the product will be used up to the level of palatability. If little meat and bone meal is available compared to the usage in formula feed, then the price will be relatively higher and the usage will be less. Figure 6 provides a comparison of the net animal protein usage for selected States. Figure 7 provides both the ratio of dairy concentrate fed to mature sheep meat and bone meal produced and the ratio of animal protein produced to that used in formula feeds. The States with low ratios of dairy concentrate fed to sheep meat and bone meal produced **combined** with high ratios of animal protein produced to feed usage have the highest risk of BSE occurrence according to the systems model. Consequently some States with relatively few dairy cattle but a lot of mature sheep rendering, such as Colorado, appear to be at higher risk than some States with large dairy populations such as Iowa.

Figure 5

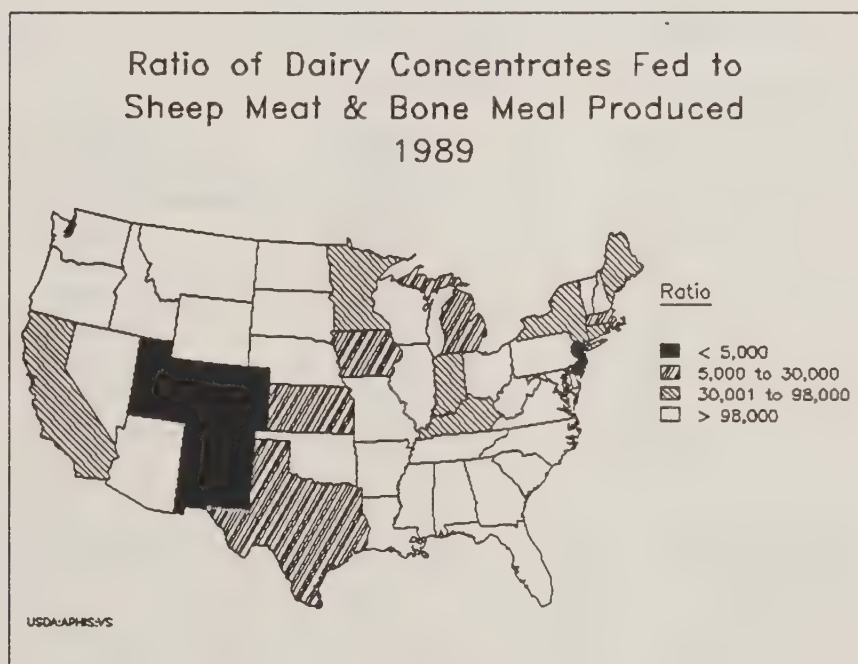




Figure 6

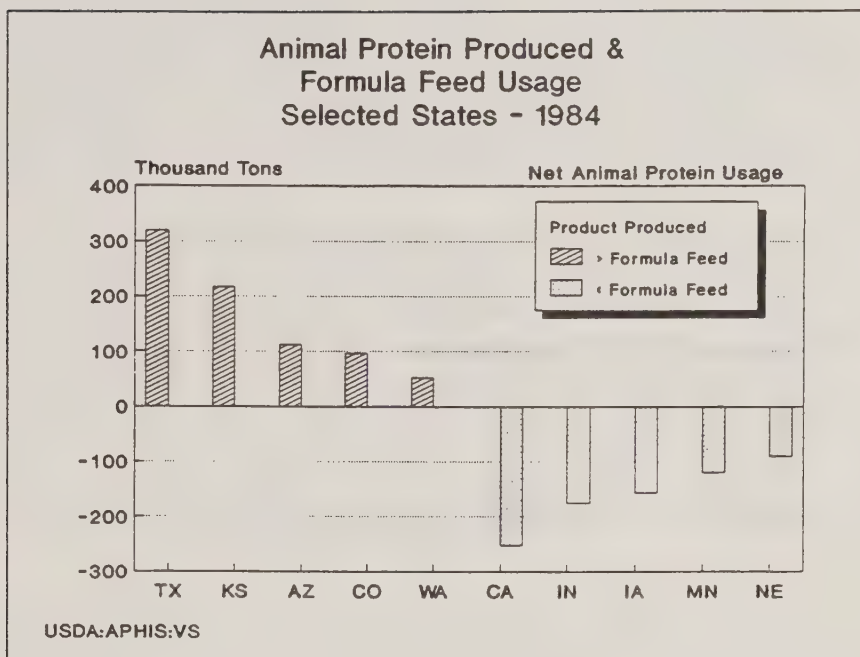


Figure 7

**Animal Protein Produced and Formula Feed Usage  
Selected States - 1984**

State	Dairy Concentrate Fed/Sheep MBM	Animal Protein Prod. /Feed Usage
Michigan	14,639	1.2
Texas	14,439	4.0
Massachusetts	14,106	
Kansas	13,032	3.1
Iowa	8,376	.7
Rhode Island	7,820	
Colorado	4,620	4.4
Utah	4,058	2.6
New Mexico	1,561	1.1
New Jersey	1,252	3.3

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# County-Level Quantitative Risk Assessment

The county-level analysis provided more detail than the State-level analysis and adjusted for regional differences within States. Renderers' locations were identified and a rendering trade and acquisition area was defined as the county where the renderer was located plus all of the contiguous counties. All mature sheep offal from slaughter and all dead, diseased, and downer mature sheep were estimated for each rendering area. Total mature sheep meat and bone meal produced, and dairy concentrates consumed per cow were estimated within each rendering area. The model was used to compute the ratio of dairy concentrates fed compared to mature sheep meat and bone meal produced.

The defined rendering areas contained approximately 50 percent of the total United States dairy cow population. Within individual rendering areas, the ratio of concentrate fed compared to mature sheep meat and bone meal produced varied from 22 to greater than 10 million (Figure 8). The highest risk category has the lowest ratios, eg, a ratio of 20 means only 20 pounds of dairy concentrate fed per pound of sheep meat and bone meal produced. Only 0.06 percent of the United States dairy cattle exist in counties with the highest risk (ratios below 100).

Wide variations exist in the number of dairy cattle located in high risk areas of individual States (Figure 9). On a regional basis, the largest number of cows in high risk areas are located in the Upper Midwest (Figure 10).

The next step in the risk assessment was to incorporate the cumulative reported incidence of scrapie over the last decade (1980-1990) into the systems model. The presence of documented scrapie flocks in a specific rendering area was considered to incriminate all mature sheep meat and bone meal as potentially contaminated. The ratios of reported scrapie flocks per 100 flocks and per 10,000 ewes varied widely across the States (Figure 11).

Six risk categories were identified based on the reported presence of scrapie in specific rendering areas and the number of dairy cows in areas with low ratios of dairy concentrates fed to total mature sheep meat and bone meal produced (Figure 12). Six States (Iowa, Indiana, Kentucky, Michigan, New Jersey, and Texas) had at least one county with documented scrapie in a rendering area and dairy cows with ratios less than 999 pounds of dairy concentrate fed to mature sheep meat and bone meal produced (Figure 13).

Figure 8

Ratio of Dairy Concentrate Fed to Sheep MBM (MBM = Meat & Bone Meal from Sheep Slaughter & Dead Sheep)		
Concentrate Fed/ Sheep MBM Produced	# of Cows	% of Cows
I. 20-99	5,757	.06%
II. 100-999	85,194	.8%
III. 1,000-9,999	621,079	6.2%
IV. 10,000-99,999	1,950,981	19.3%
V. 100,000-9,999,999	1,972,392	19.6%
VI. > or = 10,000,000	371,162	3.7%
Cows Not Considered at Risk	<u>5,078,132</u>	<u>50.4%</u>
	10,084,697	100.0%
USDA:APHIS:VS		



Figure 9

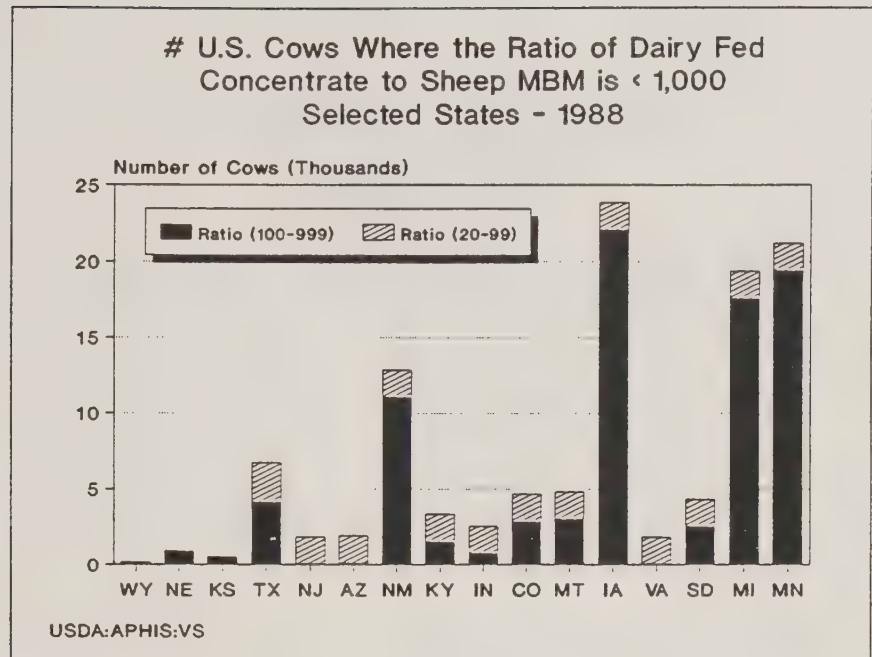
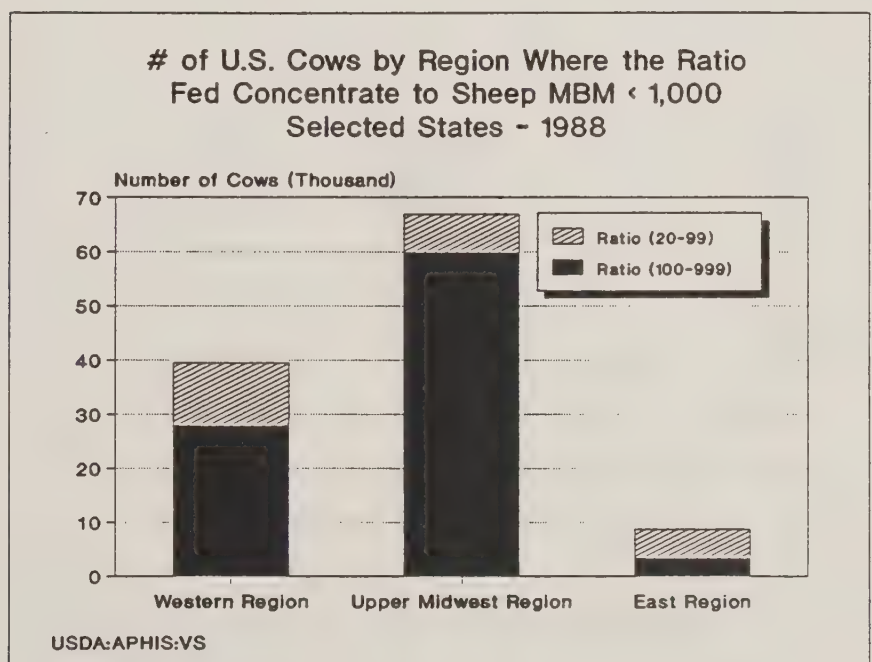


Figure 10







**Cumulative Reported Incidence of Scrapie, 1980-1990  
AND Ratio of Dairy Concentrate Fed to  
Sheep MBM\* Produced  
Selected States**

State	Reported Flocks	Incidence Per		# Cows Where Ratio	
		100 Flocks	10,000 Ewes	20-99	100-999
MI	44	2.37	7.09		17,557
IN	43	1.55	7.66		746
NJ	7	1.26	9.22	18	1,793
VA	7	0.35	0.71		14
CO	5	0.28	0.16		2,857
KY	2	0.23	0.83		1,515
TX	10	0.15	0.08	4,163	2,572
KS	3	0.14	0.23	478	19
IA	9	0.11	0.32		22,083
NE	2	0.08	0.16	939	
WY	1	0.07	0.02	169	
MN	1	0.03	0.07		19,378

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\*Meat and Bone Meal from Sheep &gt; = 1 year.

Figure 11

**BSE Risk Categories**

	<u>Scrapie Reported Locally</u>	<u>Scrapie Reported State</u>	<u>Ratio* &lt; 999</u>	<u>Ratio* &lt; 9,999</u>
I.	yes	---	yes	---
II.	no	yes	yes	---
III.	no	yes	no	> 10%
	no	no	> 10%	---
IV.	no	yes	no	yes
V.	no	yes	---	---
	no	no	no	< 10%
VI.	no	no	no	no

\*Ratio of Dairy Concentrate Fed to Sheep Meat&amp;Bone Meal Prod.

USDA:APHIS:VS

Figure 12



## State Risk Categories Based on Scrapie Reported and the Ratio of Dairy Concentrates Fed to Sheep MBM Produced\*\*

State	Risk	--Number of--		Scrapie	---Incidence per---		-Number of Cows with Ratio*-			Milk Cow	F+G+H/I
		Ewes	Flocks	Flocks	100 Flocks	10K Ewes	20-99	100-999	1,000-9,999	Inventory	Percent
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
IA	1	280,591	8,089	9	0.11	0.32		22,083	38,045	294,888	20.4
IN	1	56,143	2,771	43	1.55	7.66		746	259	163,867	0.6
KY	1	24,040	854	2	0.23	0.83			1,515	224,267	0.7
MI	1	62,036	1,857	44	2.37	7.09		17,557		344,550	5.1
NJ	1	7,591	554	7	1.26	9.22	18	1,793	660	32,067	7.7
TX	1	1,321,967	6,714	10	0.15	0.08	4,153	2,572	36,972	356,538	12.3
CO	2	307,818	1,759	5	0.28	0.16		2,857	58,484	76,285	80.4
KS	2	129,607	2,195	3	0.14	0.23	478	19	19,036	96,675	20.2
MN	2	149,797	3,959	1	0.03	0.07		19,378		709,832	2.7
NE	2	128,551	2,606	2	0.08	0.16	939		21,391	105,168	21.2
VA	2	98,800	1,980	7	0.35	0.71		14	11,304	157,128	7.2
WY	2	583,602	1,439	1	0.07	0.02	169		353	9,287	5.6
CA	3	563,300	4,064	17	0.42	0.30			145,776	1,070,366	13.6
DE	3	1,006	45	1	2.22	0.94			5,432	9,354	58.1
ME	3	9,915	495	6	1.21	6.05			29,190	49,815	58.6
MT	3	391,838	2,423	0	0.00	0.00		3,011		26,879	11.2
NM	3	305,928	1,183	0	0.00	0.00		11,029	233	58,606	19.2
OR	3	294,615	3,821	4	0.10	0.14			38,236	95,325	40.1
PA	3	74,267	2,943	13	0.44	1.75			83,421	673,054	12.4
UT	3	438,810	1,781	1	0.06	0.02			59,942	76,610	78.2
ID	4	202,144	1,300	2	0.15	0.10			11,352	157,665	7.2
IL	4	91,724	3,706	8	0.22	0.87			16,231	186,371	8.7
MD	4	15,198	589	4	0.68	2.63			1,428	110,463	1.3
NC	4	9,876	458	3	0.66	3.04			8,129	110,127	7.4
NH	4	5,794	318	3	0.94	5.18			2,203	25,110	8.8
NY	4	47,820	1,696	11	0.65	2.30			22,529	814,461	2.8
OH	4	149,598	5,085	106	2.08	7.09			2,419	347,305	0.7
TN	4	9,944	501	5	1.00	5.03			1,781	180,390	1.0
AZ	5	164,290	381	0	0.00	0.00		87		86,280	0.1
CN	5	5,020	284	0	0.00	0.00			1,191	41,691	2.9
GA	5	6,101	276	1	0.36	1.64				97,763	
LA	5	7,040	499	4	0.80	5.68				83,381	
MA	5	9,597	521	1	0.19	1.04				36,913	
MO	5	67,801	2,382	10	0.42	1.47				242,039	
MS	5	3,282	166	0	0.00	0.00			5,041	71,834	7.0
OK	5	69,692	1,493	40	2.68	5.74				90,499	
SC	5	978	62	2	3.23	20.4				40,113	
SD	5	407,767	3,726	0	0.00	0.00		2,533	41	137,020	1.9
WA	5	37,668	1,450	6	0.41	1.59				220,849	
WI	5	62,683	2,444	15	0.61	2.39				1,743,427	
WV	5	52,653	1,451	1	0.07	0.19				27,019	
AR	6	7,155	303	0	0.00	0.00				70,926	
AL	6	3,262	172	0	0.00	0.00				45,994	
FL	6	6,579	241	0	0.00	0.00				176,993	
ND	6	115,691	1,502	0	0.00	0.00				96,366	
NV	6	66,256	349	0	0.00	0.00				17,646	
RI	6	1,001	69	0	0.00	0.00				2,975	
VT	6	12,824	542	0	0.00	0.00				178,967	

## Risk Level Analysis:

- I: Scrapie is reported in the same or adjacent counties as milk cows having a ratio less than 999.  
 II: Scrapie is reported in the state and milk cows have a ratio less than 999.  
 III: Scrapie is reported in the state and at least 10 percent of the milk cows have a ratio less than 9,999.  
Or no scrapie is reported but at least 10 percent of the milk cows have a ratio less than 999.  
 IV: Scrapie is reported in the state and at least some portion of milk cows have a ratio less than 9,999.  
 V: Scrapie is reported in the state.  
Or no scrapie is reported but up to 10 percent of the milk cows have a ratio less than 9,999.  
 VI: No scrapie is reported and no cows have a ratio less than 9,999.

\*The ratio is inversely related to potential risk, i.e. (F) is highest risk.

SOURCE: USDA/APHIS/VS

\*\*Meat and bone meal from sheep > 1 year.

Figure 13





## Conclusions

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The state and county-level quantitative risk assessments substantiate the conclusions of the qualitative comparison of risk factors between the United States and United Kingdom. Little evidence exists to support a broad risk for BSE among a large portion of the dairy population of the United States. This conclusion is supported by the fact that the proportion of animal proteins produced from mature sheep is extremely low. Substantial geographic variation exists in the ratio of dairy concentrates fed to the sheep meat and bone meal produced. Despite this variation, low ratios of dairy concentrates fed to sheep meat and bone meal produced affect very few cows.

These conclusions must be considered cautiously, since the analysis required a number of simplifying assumptions concerning the rendering industry and feed formulation and usage. Seasonal variation exists in the availability of sheep meat and bone meal as well as competing feed substitutes, therefore, feed formulations may vary considerably, compounding the problem of accurately estimated consumption of mature sheep meat and bone meal by dairy cattle. In addition, the entire risk assessment considers scrapie infected sheep as the only source of the BSE agent.



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